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Research Notes: Screening soybean germplasm for multiple pest resistance

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selection response reported here. The favorable yield response observed in this population suggests that recurrent selection is a viable scheme for the development of populations of greater diversity as well as productivity.

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1) Field screening of soybean germplasm (Maturity Groups 00 to IV) against *H. zea* damage.*

Genetic base of major commercial soybean cultivars is very narrow. The top 10 most widely grown cultivars in the U.S. have been developed from 17 parent lines (Hartwig, 1973). Recently three soybean Plant Introductions, namely, PI 171.451, PI 227.687 and PI 229.358, have been found to have good leaf-feeding resistance to Mexican bean beetle (*Epilachna varivestis* Mulsant) (Van Duyn *et al*., 1972) and corn earworm (*Heliothis zea* Boddie) (Hatchett *et al*., 1976; Joshi and Wutoh, 1976). Most of the plant breeders are using these three PI's very extensively in developing varieties resistant to various insect pests of soybeans. This practice may again result in a narrow genetic base of resistant cultivars. The objective of this investigation was to screen soybean germplasm from Maturity Groups 00 to IV for resistance to *H. zea* under field conditions.

Materials and methods: During 1974, 30 seeds of each germplasm entry and some advanced breeding lines, totaling 2797, were planted in the field in rows 36" long and 36" apart. Resistant germplasm with yellow seed coat (550 entries) was again planted during 1975. Field plantings were made up to May 28 during 1974 and on May 28 during 1975. Pods of each cultivar were examined for *H. zea* damage at maturity. Cultivars with no damaged pods were classified

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as resistant.

Results and discussions: Out of 2797 germplasm entries tested in the field, 625 (22%) were not damaged by this pest during 1974. Out of 625 germplasm entries, 550 cultivars were again tested in the field during 1975. It was found that only 461 out of 550 were not damaged by this pest for two years. The list of resistant germplasm follows:

Maturity Group 00

Ada	PI 377.422	PI 189.877	PI 194.639
Portage	PI 372.406	PI 189.880	PI 194.643
PI 360.962	PI 153.293	PI 189.886	PI 194.644
PI 347.540[A]	PI 154.198	PI 153.314	PI 194.645
PI 347.540[B]	PI 180.507	PI 189.906	PI 194.647
PI 361.068	PI 180.508	PI 189.932	PI 196.485
PI 361.078	PI 180.509	PI 189.937	PI 196.486
PI 361.086	PI 180.516	PI 194.624	PI 196.491
PI 361.107	PI 180.517	PI 194.627	PI 196.504
PI 361.108	PI 180.519	PI 194.630	PI 198.067
PI 372.403[B]	PI 180.525	PI 194.632	PI 240.079

Forty-four cultivars/PI's were found to be resistant in Maturity Group 00.

Maturity Group 0

Capital	PI 347.568	PI 153.261	PI 370.402
Grant	PI 347.570	PI 161.989	PI 372.403[C]
PI 290.133	PI 153.213	PI 290.116[A]	PI 372.424
PI 297.507[B]	PI 361.061[A]	PI 347.567	FC 30.684
PI 297.513	PI 361.077[B]	PI 154.189	PI 189.898
PI 347.559[B]	PI 361.091	PI 189.897	PI 189.900
FC 30.684	PI 181.531	PI 347.559[A]	PI 189.913
PI 68.722	PI 181.571	PI 361.120	PI 204.652
PI 70.242-4	PI 189.882	PI 370.057[A]	PI 227.330
PI 153.259	PI 189.893	PI 370.058	PI 238.924

Forty cultivars/PI's were found to be resistant in Maturity Group 0.

Maturity Group I

Blackhawk	PI 358.319	PI 68.770	PI 88.295
Bombay	PI 362.092	PI 70.016	PI 88.443
Disoy	PI 361.095	PI 70.017	PI 88.805-2
Earlyana	PI 361.098	PI 70.087	PI 89.055
Habaro	PI 361.104	PI 70.473-1	PI 153.263
PI 291.294	PI 370.059	PI 70.520	PI 153.283
PI 291.303[A]	PI 54.853	PI 71.161	PI 181.536
PI 297.514	PI 68.551-3	PI 70.241	PI 181.538
PI 342.437	PI 68.554	PI 79.699	PI 153.308
PI 347.546[B]	PI 68.572	PI 81.037-4	PI 189.966
PI 358.315[A]	PI 68.586	PI 81.775	PI 227.322

Maturity Group I (cont'd)

PI 361.066[A]	PI 68.610	PI 84.686	PI 227.329
PI 361.066[B]	PI 68.746	PI 84.964	PI 189.916
PI 361.087		PI 86.416	

Fifty-four cultivars/PI's were found to be resistant in Maturity Group I.

Maturity Group II

Amsoy	PI 68.670-1	PI 68.788	PI 73.583
Beeson	PI 68.670-2	PI 68.795	PI 73.585
Corsoy	PI 68.671	PI 69.500	PI 79.613
Goku	PI 68.686	PI 69.512	PI 79.862-1
Harosoy 63	PI 68.680	PI 70.009	PI 79.863
Harwood	PI 68.687	PI 70.021	PI 84.965
Linman 533	PI 68.694	PI 70.036	PI 85.508
Madison	PI 68.704	PI 70.077	PI 86.741
Provar	PI 68.706	PI 70.078	PI 86.878
SRF 200	PI 68.708	PI 70.084	PI 88.293[A]
PI 248.396	PI 68.709	PI 70.197	PI 88.294-1
PI 253.650[B]	PI 227.334	PI 70.224	PI 88.301
PI 68.516	PI 266.085[C]	PI 70.228	PI 88.355
PI 68.521	PI 291.290	PI 70.242	PI 88.803
PI 68.522	PI 291.291	PI 70.457	PI 88.810
PI 68.526	PI 291.296	PI 70.459	PI 71.850
PI 68.530	PI 291.298	PI 70.461	PI 88.495
PI 68.543	PI 291.309[A]	PI 70.463	PI 89.004
PI 61.551-2	PI 347.539[A]	PI 70.503	PI 89.072
PI 68.555	PI 347.539[B]	PI 70.516	PI 91.132-2
PI 68.564	PI 360.840	PI 361.065[B]	PI 91.167
PI 68.587	PI 68.712	PI 361.080	PI 92.465
PI 68.598	PI 68.713	PI 361.074	PI 92.583
PI 68.600	PI 68.715	PI 361.109	PI 92.611
PI 68.609[LB]	PI 68.718	PI 361.116	PI 92.677
PI 68.622	PI 68.725	PI 370.057[B]	PI 92.683
PI 68.627	PI 68.728	PI 54.604	PI 92.719
PI 68.629	PI 68.729	PI 68.475	PI 181.537
PI 68.639	PI 68.762	PI 68.475-1	PI 189.930
PI 68.642	PI 68.765	PI 68.500	PI 200.479
PI 68.658	PI 68.778	PI 68.503	PI 227.321
PI 68.661		PI 68.508	

One-hundred and twenty-six cultivars/PI's were found to be resistant in Maturity Group II.

Maturity Group III

Adelphia	SRF 350	PI 68.535	PI 70.541
AK (Harrow)	PI 253.660[A]	PI 68.621	PI 70.566
Bavender Special A	PI 283.331	PI 68.679	PI 70.461
Bavender Special B	PI 291.286	PI 68.701	PI 71.845
Chusei	PI 291.310[C]	PI 68.710	PI 88.291
Dunfield	PI 297.504	PI 68.731	PI 88.297

Maturity Group III (cont'd)

Harman	PI 361.063	PI 68.732-1	PI 88.303-1
Illington	FC 02.108	PI 68.748-1	PI 88.306
Jogun (Ames)	PI 68.398	PI 68.761-3	PI 88.312
Lincoln	PI 68.423	PI 68.806	PI 88.349
Manchu Lafayette	PI 68.494	PI 90.463	PI 88.353
Ross	PI 68.521-1	PI 90.566	PI 88.354
Viking	PI 79.797	PI 89.150	PI 89.002
PI 69.515	PI 79.835	PI 90.578	PI 89.005-4
PI 69.995	PI 79.872	PI 91.153	PI 89.061-2
PI 70.001	PI 79.848-1	PI 92.602	PI 89.066
PI 70.014	PI 80.822	PI 92.608	PI 90.392
PI 70.023	PI 82.232	PI 92.617	PI 181.554
PI 70.076	PI 84.682	PI 92.623	PI 153.309
PI 70.080	PI 84.908-2	PI 98.243	PI 189.920
PI 70.188	PI 85.668	PI 157.457	PI 196.148
PI 70.192	PI 85.878	PI 157.491	PI 196.156
PI 70.199	PI 86.026-1	PI 70.462	PI 196.157
PI 70.201	PI 86.123	PI 70.470	PI 200.453
PI 70.202	PI 87.574	PI 70.471	PI 200.457
PI 70.212	PI 87.634	PI 70.473	PI 200.480
PI 70.213	PI 238.334	PI 70.500	PI 200.548
PI 70.247	PI 68.530-2	PI 70.501	PI 226.588
PI 70.019	PI 68.533-1	PI 70.519	PI 227.560
PI 89.012-1	PI 68.533-2	PI 70.528	PI 227.686
PI 243.532	PI 88.282	PI 92.618	PI 235.339
Williams			

One-hundred twenty-five cultivars/PI's were found to be resistant in Maturity Group III.

Maturity Group IV

Bethel	PI 243.525	PI 54.617	PI 92.689
Bonus	PI 243.528	PI 61.944	PI 157.459
Clark	PI 340.017	PI 62.248	PI 172.901
Clark 63	PI 246.366	PI 68.644	PI 181.550
Cutler 71	PI 246.367	PI 68.679-2	PI 181.557
Cypress No. 1	PI 253.651[A]	PI 70.208	PI 157.419
Fabulin	PI 253.651[B]	PI 71.444	PI 157.437
Hokkaido	PI 253.651[D]	PI 71.506	PI 157.452
Harbinsoy	PI 71.463	PI 79.825-1	PI 200.470
Higan	PI 253.652[B]	PI 84.960	PI 200.536
Kailua	PI 253.654	PI 86.876	PI 205.088
Kaikoo	PI 253.656[A]	PI 87.631-3	PI 226.591
Macoupin	PI 253.661[C]	PI 88.302-1	PI 228.064
Makapu Summer	PI 266.806[D]	PI 88.499	PI 229.314
Perry	PI 274.210	PI 88.814	PI 229.319
Roe	PI 340.010	PI 88.820[N]	PI 229.325
Scioto	PI 340.012	PI 89.010	PI 235.335
Scott	PI 360.845	PI 89.128	PI 235.346
SRF 450	PI 361.103	PI 90.492-2	PI 235.651[B]

Maturity Group IV (cont'd)

SRF 425	FC 03.654-1	PI 91.133	PI 90.402
PI 243.514	FC 19.979-3	PI 91.731-1	

Eighty-three cultivars/PI's were found to be resistant in Maturity Group IV.

Recent data from other field experiments at UMES (unpublished) and by other investigators (Deitz et al., 1976) indicate that early planted soybeans escape damage from this pest. Therefore, some of these cultivars might have shown resistance through escape mechanism. It is hoped that plant breeders engaged in developing resistant varieties to various insect pests of soybeans may want to look at these germplasm entries more critically.

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2) Mechanism of corn earworm resistance in some soybean cultivars.*

Much emphasis is being placed on the development of new soybean (*Glycine max* (L.) Merrill) cultivars resistant to various insect pests. Three soybean PI's (171.451, 229.358, 227.687) have been found to have antibiosis to Mexican

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bean beetle (Epilachna varivestis Mulsant) (Van Duyn et al., 1972) and corn earworm (Heliothis zea Boddie) (Clark et al., 1972; Hatchett et al., 1976; Joshi and Wutoh, 1976). These PI's also have exhibited resistance to bean leaf beetle (Cerotoma trifurcata Foster); cultivars 'Shore' and 'Wye' also were observed to have leaf feeding resistance to this pest (Joshi and Wutoh, 1976). The objective of this study was to investigate mechanism of resistance in Shore, Wye and 'ED 73-371' to H. zea.

Materials and methods: Six cultivars ('Davis', PI 229.358, PI 227.687, Wye, Shore, ED 73-371) were planted in the field on May 17, 1976. Davis (Beland and Hatchett, 1976; Hatchett et al., 1976) and an artificial diet (supplied by Bio-Serv, Frenchtown, NJ) were susceptible checks, and two PI's (229.358, 227.687) were resistant checks. On July 26, 1976, when plants were in 7th to 9th trifoliolate stage, foliage feeding was started. Three newly-hatched larvae (<24 hours old) were placed in each cup (50 cups/treatment) along with a leaflet from the first fully expanded trifoliolate of each cultivar. Sufficient artificial diet was placed in each cup in the beginning and more was added when necessary for artificial diet treatment. After 72 hours, larvae were thinned out to one/cup. Mean minimum and maximum temperatures during experimentation were 74.4°F and 76.6°F. Larval weight (after 10 and 15 days), pupal weight (on 6th day after pupation), length of larval and pupal stage were recorded. Larvae were checked for mortality daily. Other techniques of feeding and rearing were the same as reported in an earlier publication (Joshi and Wutoh, 1976).

Results and discussion: The effect of different feeding treatments on some growth parameters is given in Table 1. H. zea larvae reared on artificial diet had maximum larval and pupal weight, shortest larval and longest pupal stage, and lowest mortality as compared with other treatments, whereas PI 227.687 offered maximum leaf feeding resistance with lowest larval and pupal weights, greatly extended larval stage and maximum mortality. Larval and pupal mortality on PI 227.687 was 36%. This mortality is very low as compared with Hatchett et al. (1976) who have reported 100% mortality on this PI. It appears that environments under which cultivars are grown and feeding test conducted, have profound effect on the expression of antibiosis.

Shore and PI 227.687 exhibited more antibiosis after 10 days feeding as expressed in low larval weight than any other treatment. Larvae reared on Wye, PI 229.358 and ED 73-371 also gained less weight than those reared on

Table 1

Development of <u>Heliothis zea</u> larvae on synthetic diet and leaves of different soybean cultivars or PI's

Treatment†	$\bar{x}$ (mg) Larval wt. after 10 days	$\bar{x}$ (mg) Larval wt. after 15 days	$\bar{x}$ (mg) Pupal wt.††	Days in larval stage	Days in pupal stage	Larval mortality 1-10th day	Larval mortality 11-15th day	Larval mortality 16th-pupation	Larval mortality Total larval mort.	pupal mort.	Total mort. (%)
Control (synthetic diet)	631a*	----	432a*	14.9e*	14.5a*	2	0	0	2	2	8
Davis	225b	454b*	315c	17.8d	13.1b	3	1	2	6	2	16
ED 73-371	145c	534a	345b	18.9c	13.3b	4	2	1	7	4	22
PI 229.358	135c	529a	360b	18.9c	13.1b	5	0	2	7	4	22
Wye	134c	503ab	342b	19.6bc	13.0b	3	0	4	7	4	22
Shore	89d	445b	315c	19.9b	12.8b	4	0	4	8	2	20
PI 227.687	70d	213c	274d	23.7a	13.1b	13	2	1	16	2	36

*Means not followed by the same letter were significantly different at the 0.05 probability level according to Duncan's Multiple Range Test.

†50 larvae/treatment.

††Mean weight of pupae on sixth day after pupation.

Davis in the same feeding period. However, larval weight after 15 days indicated no difference among ED 73-371, PI 229.358 and Wye; although the larvae reared on these cultivars gained more weight than on Davis, Wye and Shore. It appears that with the exception of Davis, larvae ≤10 days old were unable to feed satisfactorily on these cultivars, whereas no leaf feeding resistance was observed for any other cultivar except PI 227.687 when the larvae were 11 to 15 days old.

Leaf feeding resistance to H. zea, up to first 10 days, in ED 73-371, PI 229.358, Wye and Shore may be biophysical in nature but the antibiosis expressed by PI 227.687 may be due to nutritional deficiency or nutrient disproportionality as indicated by low larval weight and extended larval stage.

Acknowledgements: Thanks are expressed to Drs. E. E. Hartwig, Sam G. Turnipseed for supplying seeds and Dial F. Martin for supplying H. zea eggs. Technical assistance of Mr. Oswald Andrade is also acknowledged.

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3) Screening soybean germplasm for multiple pest resistance.*

Use of resistant soybean cultivars is an excellent method of controlling various insect pests and diseases. A resistant plant has built-in protection which lasts throughout the growing season. Cultivars having resistance to

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only one pest may still need chemical control measures for protection from other pests. However, development of cultivars with multiple pest resistance can eliminate the use of poisonous chemicals. Downy mildew caused by Peronospora manshurica (Naoum) is one of the serious soybean diseases which can reduce yield by 8% (Athow, 1973) and among the insect pests, corn earworm (Heliothis zea Boddie) is one of the most destructive pests of this crop. Corn earworm infestation sometimes can cause complete crop loss (Turnipseed, 1973).

The present investigation was undertaken to screen maturity group V germplasm for downy mildew and corn earworm resistance under field conditions.

Materials and methods: Fifty seeds of each of the 248 cultivars/PI's were planted in the field June 5, 1975. Cultivars/PI's were examined for pod damage by corn earworm. Soybean cultivars which had one or more damaged pods were classed as susceptible and the others without any damage were classified as resistant. All cultivars were also checked for downy mildew infestation Sept. 3, 1975.

Experimental results and discussion: Soybean cultivars which did not show any symptoms of downy mildew are as follows:

Dorman	PI 123.577	PI 238.929
Dortchsoy 67	PI 157.413	PI 238.932
Arlington	PI 157.443	PI 274.422
Hollybrook	PI 157.444	PI 274.508
Luthv	PI 157.451	Dixie
Austin	PI 157.470	Lexington
FC 30.265	PI 157.473	PI 303.652
FC 31.719	PI 157.493	PI 319.527
FC 31.934	PI 170.896	PI 319.528
FC 31.952	PI 171.430	PI 319.532
PI 60.269	PI 171.442	PI 339.867
PI 60.273	PI 179.823	PI 339.869
PI 60.296	PI 179.825	PI 381.670
PI 62.203	PI 181.543	PI 339.980
PI 62.204	PI 181.547	PI 339.989
PI 71.465	PI 181.562	PI 339.992
PI 71.677	PI 187.155	PI 339.998
PI 79.832	PI 196.166	PI 339.999
PI 80.466	PI 200.447	PI 340.000
PI 81.042	PI 200.450	PI 340.003
PI 81.780-S	PI 200.468	PI 340.004
PI 82.286	PI 200.495	PI 340.006
PI 82.588	PI 200.503	PI 340.008
PI 83.836	PI 200.510	PI 340.013
PI 83.942	PI 200.534	PI 340.014
PI 84.632-S	PI 200.546	PI 340.016

PI 84.734	PI 209.333	PI 340.026
PI 84.910	PI 210.179	PI 340.029
PI 85.089	PI 219.780	PI 340.043
PI 85.252	PI 219.785	PI 340.045
PI 86.045-S	PI 219.789	PI 342.003
PI 86.465	PI 221.973	PI 346.306
PI 86.982	PI 227.158	PI 346.309
PI 87.037	PI 227.159	PI 355.067
PI 88.490	PI 227.555	PI 355.069
PI 88.820	PI 227.567	PI 355.070
PI 89.061	PI 229.315	PI 371.610
PI 89.154-S	PI 229.335	PI 371.611
PI 90.243	PI 229.337	PI 381.659
PI 90.481	PI 229.346	PI 381.663
PI 91.725	PI 229.350	PI 381.655
PI 95.959	PI 235.347	PI 381.668
PI 96.169	PI 238.928	

One-hundred twenty-eight out of 248 were found to be resistant to downy mildew during 1975 screening program.

Corn earworm resistance: Cultivars which did not sustain any pod damage from corn earworm are listed as follows:

Dorman	PI 157.394	PI 340.009
Dortchsoy 67	PI 157.451	PI 340.019
Harrel	PI 157.470	PI 340.044
Arlington	PI 170.893	PI 340.051
Nansemond	PI 181.544	PI 342.002
Peking	PI 181.546	PI 342.003
S-100	PI 181.558	PI 371.610
FC 30.265	PI 196.177	PI 371.611
FC 31.683	PI 200.450	PI 381.662
FC 31.721	PI 235.347	PI 381.664
PI 60.273	PI 238.928	PI 381.666
PI 62.203	PI 274.422	PI 381.667
PI 65.342	Lexington	PI 381.670
PI 71.465	PI 322.693	PI 381.671
PI 79.832	PI 322.694	PI 381.673
PI 81.780-S	PI 324.924	PI 381.674
PI 82.588	PI 346.307	PI 381.675
PI 83.942	PI 346.308	PI 381.676
PI 87.542	PI 339.866	PI 381.677
PI 95.959	PI 339.978	PI 381.678
PI 96.089	PI 339.982	PI 381.684
PI 96.786	PI 339.998	

Sixty-five cultivars/PI's out of 248 were observed to be resistant to corn earworm under field conditions during 1975.

Multiple resistance: Cultivars with resistance to both downy mildew and corn earworm are as follows:

Dorman	PI 82.588	Lexington
PI 60.273	PI 157.470	PI 371.611
PI 81.780-S	PI 274.442	FC 30.265
PI 157.451	PI 371.610	PI 79.832
PI 238.928	Arlington	PI 95.959
PI 342.003	PI 71.465	PI 235.347
Dortchsoy 67	PI 83.942	PI 339.998
PI 62.203	PI 200.450	PI 381.670

Twenty-four cultivars/PI's were found to have field resistance to both of these pests.

The use of diversified germplasm with multiple pest resistance in developing cultivars resistant to various pests will greatly reduce the need of chemical control measures.

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1) Evaluation of some soybean isolines in irrigation culture.*

About 9% of the total soybean acreage and about 50% of the total corn acreage in Nebraska was irrigated at least once during the growing season in 1975. The 1975 state averages for irrigated soybeans and irrigated corn were

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